The Recoil product Transfer Chamber (RTC): A new interface for heavy element chemistry studies at the Berkeley Gas-filled Separator

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Fast, efficient and element-specific separation techniques are necessary to study the chemical properties of the heaviest elements produced in fusion reactions with very low cross sections. Specific chemical reactions are used to compare the chemical behavior of the heavy elements with the behavior of the expected homologues [1, 2]. To improve the sensitivity of the experiments, we are combining the Berkeley Gas-filled Separator (BGS) with a chemical separation system. The BGS separates the compound nucleus from transfer products originating from target impurities and long-lived spontaneous fission products. This improves the ability to study the chemistry of heavy elements because most of the radioactive interferences are eliminated.

The technical challenges of constructing a transfer interface between the BGS and the chemical separation system are: a) the required large pressure difference between the BGS and the interface (1 : 760 Torr) in order to transport the heavy elements to the chemistry system and b) the low kinetic energy of heavy elements created in the fusion reaction ($\leq$ 13 MeV) which need to penetrate the interface window. We designed, built, and tested a Recoil product Transfer Chamber (RTC). The chamber is separated from the BGS by a wire-grid-supported thin Mylar foil. The RTC has a movable piston to provide the different chamber depths necessary for different recoil stopping ranges. A carrier gas, entering through six gas inlets behind the foil, sweeps the activity through a hole in the piston to the chemical separation system.

We tested the RTC in three experiments to determine the transfer efficiency. In the first experiment, the reaction $^{40}Ar(^{164}Dy, xn)^{204-n}Po$ was used to measure the efficiency at the high kinetic energy of the evaporation residues (EVR) of 43 MeV. The window material was an 800 $\mu g/cm^2$ aluminized Mylar foil. The gas pressure inside the RTC and BGS was 760 and 1 Torr, respectively. The activity was transported by a helium/KCl gas-jet system through a 21-m long polyethylene capillary to our rotating wheel α-detector system (MG). The total efficiency of the transport was about 30% compared to the activity measured in the BGS. This results in a transfer efficiency of more than 50% from the BGS to the interface assuming a transport efficiency of 50-60% for the He/KCl gas-jet. In two further experiments, the reaction $^{22}Ne(^{197}Au, xn)^{219-n}Ac$ was used to measure the efficiency at the low EVR kinetic energy of 11 MeV. Using a 340 $\mu g/cm^2$ and a 210 $\mu g/cm^2$ Mylar foil, with 760 Torr and 590 Torr pressure in the RTC, the total transport efficiency was 5% and about 15%, respectively. We calculated a stopping range of 370 $\mu g/cm^2$ in Mylar for 10 MeV E_{kin} of the EVR assuming 1 MeV energy loss in the BGS at 0.2 Torr He pressure. This indicates that many of the actinium nuclei may be stopped in the 340 $\mu g/cm^2$ Mylar foil. The gas-jet transport efficiency dropped drastically with the reduced pressure necessary in the RTC to accommodate the use of thinner Mylar foils. The transport time from the BGS to the MG was 4 ± 1 s.

The experiments have shown that the RTC is working well. After improving the flow behavior to further increase the transport efficiency and the transport time, the RTC will be used to study the chemical properties of hassium (Hs, element 108) and its expected homologues ruthenium and osmium by cryo-thermochromatography of the tetroxides.

References

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2. R. Eichler et al., *Preliminary Results of an Experiment to Investigate the Chemical Properties of Bohrium (Bh, element 107)*, PSI Annual Report 1999 (2000)